AD-A194 231 UNSTEADY WATER CHANNEL(U) UNIVERSITY OF SOUTHERN CALIFORNIA LOS ANGELES DEPT OF AEROSPACE ENGINEERING C HO 29 MAR 88 AFOSR-TR-88-0466 AFOSR-85-0064 1/1

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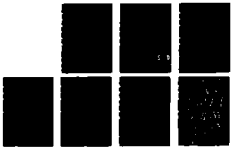

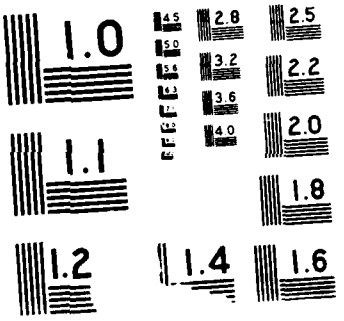
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REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b RESTRICTIVE MARKINGS
AD-A194 231	3 DISTRIBUTION AVAILABILITY OF REPORT: APPROVED FOR PUBLIC RELEASE DISTRIBUTION IS UNLIMITED
	5 MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 88-0466
6a NAME OF PERFORMING ORGANIZATION: UNIV OF SOUTHERN CA	6b OFFICE SYMBOL (If applicable):
7a NAME OF MONITORING ORGANIZATION: AFOSR/NA	
6c ADDRESS (City, State, and ZIP Code): DEPT OF AEROSPACE ENGIN L.A CA 90089	7b ADDRESS (City, State, and ZIP Code): BUILDING 410 BOLLING AFB, DC 20332-6448
8a NAME OF FUNDING SPONSORING ORGANIZATION: AFOSR	8b OFFICE SYMBOL (If applicable): NA
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR-85-0064	
8c ADDRESS (City, State, and ZIP Code): BUILDING 410 BOLLING AFB, DC 20332-6448	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO 61102F; PROJECT NO 2307; TASK NO A1; WORK UNIT ACCESSION NO
11 TITLE (Include Security Classification): (U) UNSTEADY WATER CHANNEL	
12 PERSONAL AUTHOR(S): C-M HO	
13a TYPE OF REPORT: FINAL	13b TIME COVERED: FROM 12/84 TO 12/87
14 DATE OF REPORT (Year, Month, Day): 3/88	15 PAGE COUNT: 14
16 SUPPLEMENTARY NOTATION	
17 COSATI CODES: FIELD / GROUP / SUB-GROUP	18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number): WATER CHANNEL, UNSTEADY WATER CHANNEL

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

An unsteady water channel has been constructed. The test section measures 18" by 18" and has a maximum flow rate of 3 ft/sec. In addition, a rotatin gate provides programable unsteady flow velocities.

20 DISTRIBUTION AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL: HENRY E HELIN, CAPTAIN, USAF	22b TELEPHONE (Include Area Code): 202-767-0471 / 22c OFFICE SYMBOL: AFOSR/NA

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

UNSTEADY WATER CHANNEL
AFOSR-85-0064

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29 March 1988

FINAL REPORT for period (12/31/84 - 12/30/87)

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UNSTEADY WATER CHANNEL

FINAL REPORT

AFOSR-85-0064

PRINCIPAL INVESTIGATOR: HO, CHIH-MING

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Los Angeles, California 90089-1191

INTRODUCTION

When an airplane undergoes maneuvering, the motion includes many modes: pitching, plunging, translation, acceleration and deceleration. The aerodynamics of the first three types of motion are well-documented. The effects of acceleration and deceleration on the aerodynamic forces of a wing have not been explored in depth because a specially designed unsteady testing facility is necessary. The present water channel is able to provide a wide variety of free stream conditions.

DESIGN PRINCIPLE

Careful planning is necessary, as there are many factors to consider in designing an unsteady facility. The most important operational parameter, perhaps, is the frequency of the free stream velocity because the ratio of this frequency to the characteristic frequency of the flow determines the "steadiness". In an air facility, the characteristic frequency of the flow is usually very high. It is difficult to match the free

stream frequency to the characteristic frequency. Therefore, we have chosen to build an unsteady water channel.

In unsteady aerodynamic studies, suction can be very high and it is possible that cavitation can occur on the airfoil. In order to reduce this possibility, the channel is built with a vertical configuration. The water head helps to prevent cavitation. In almost all water channel operations, air bubbles are a troublesome problem. This problem is alleviated by allowing the bubbles to travel upward to the water surface. The other advantage of having a channel with a vertical configuration is that the pump is operated in the designed high efficiency range.

Since the free stream condition is versatile, we are able to easily control the velocity as a function of time. This requirement is achieved by operating the channel in the constant head mode. In this case, the free stream velocity is a function of the flow resistance. The nonlinear characteristics of the pump do not interfere with the control. We use a three-element gate [Fig. 1] to provide a variable flow-resistance. The top two pieces have the same opening patterns and are allowed to rotate over each other to determine the mean flow. The third element is a rotating gear also with the same pattern. When the gear is driven by a stepping motor, the opening area of the gate varies with time and so does the flow resistance. Hence, the free stream speed can be controlled by using a specific angular speed of the gear.

CONFIGURATION

The channel is 12' tall [Fig.2] with the test section measuring 18" x 18". The stagnation chamber has a dimension of 42" on each side and connects to the test section through a fifth order polynomial contraction [Fig. 3]. The maximum velocity is 3 ft/sec. Two velocity traces in the prototype channel are shown in Figs. 4 & 5. When the rotating gate has a constant angular speed, the freestream speed has an irregular form [Fig. 4]. However, when the gate is controlled by a micro-processor, a precise triangular waveform is achieved [Fig. 5].

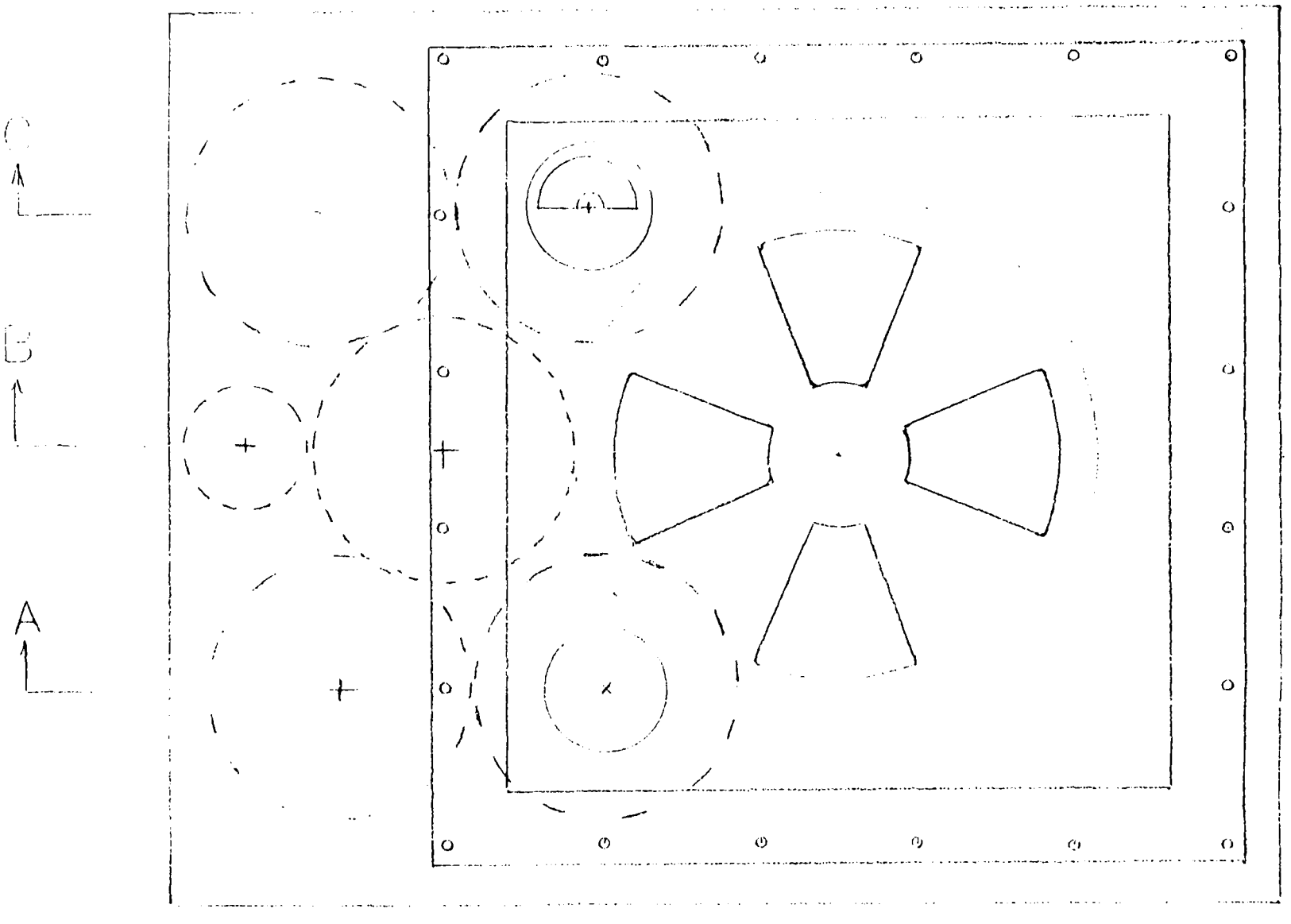

Fig. 1. The three-element gate.

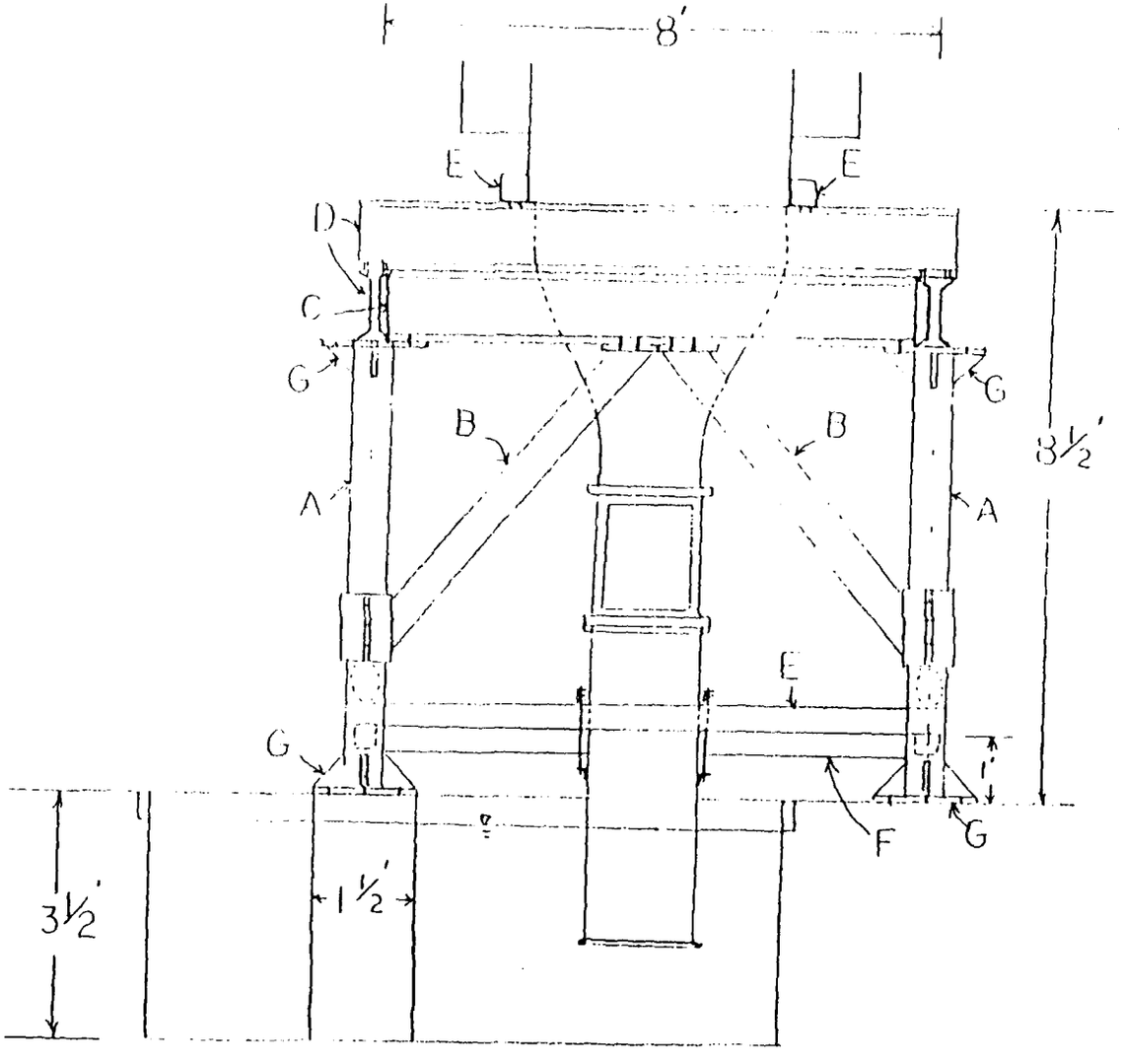

Fig. 2. The configuration of the unsteady water channel.

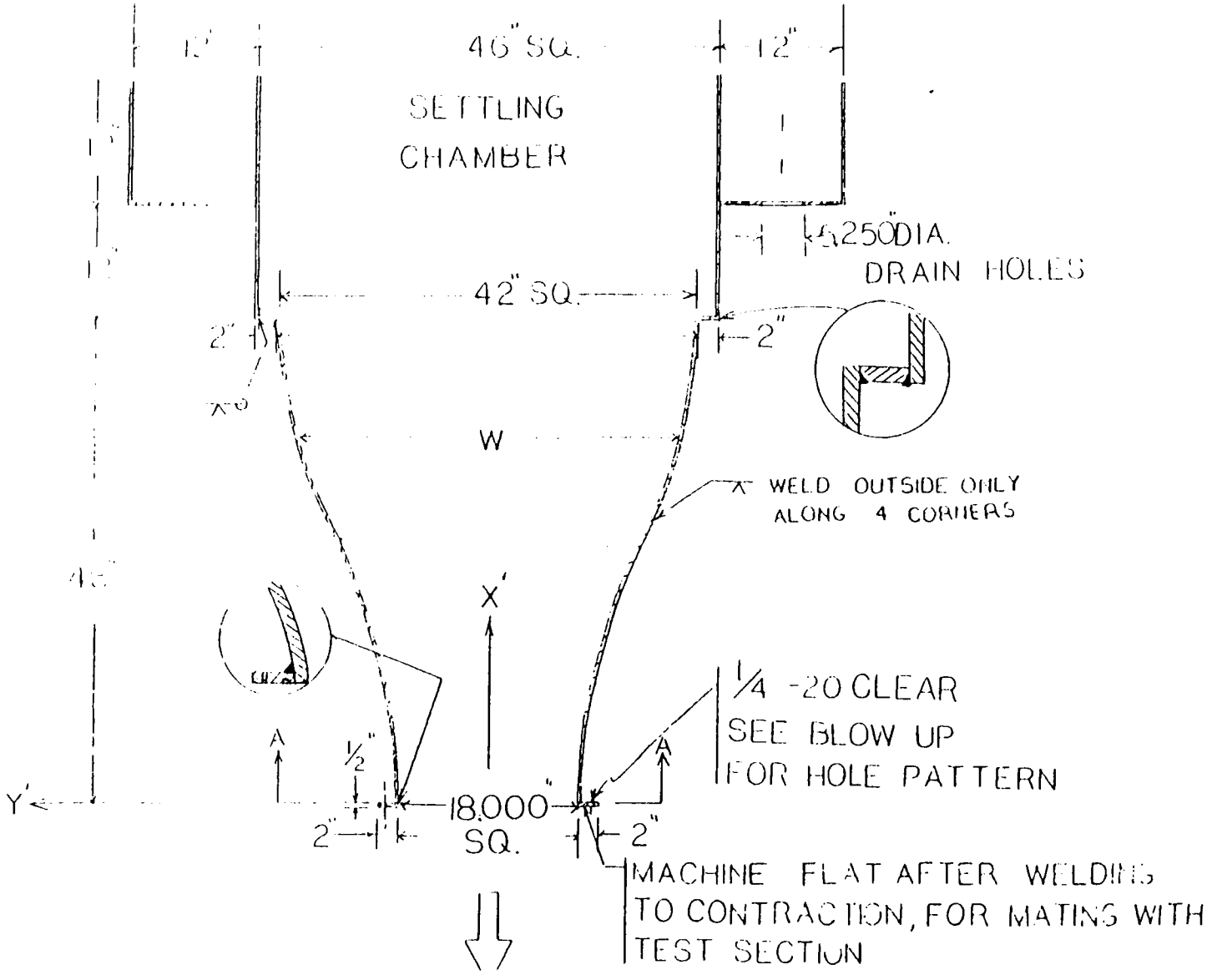

Fig. 3. The contraction section.

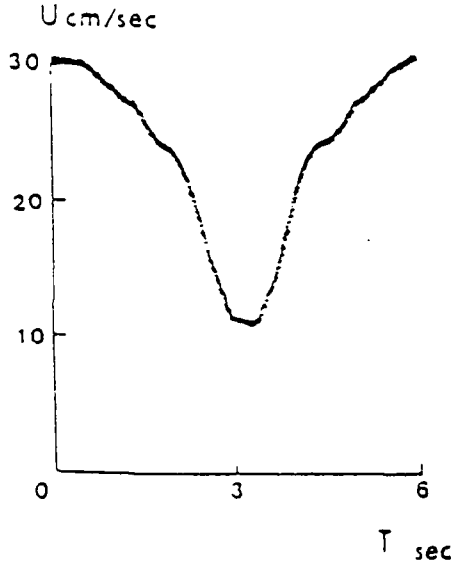

Fig. 4. Free stream velocity with rotating gate at constant angular speed.

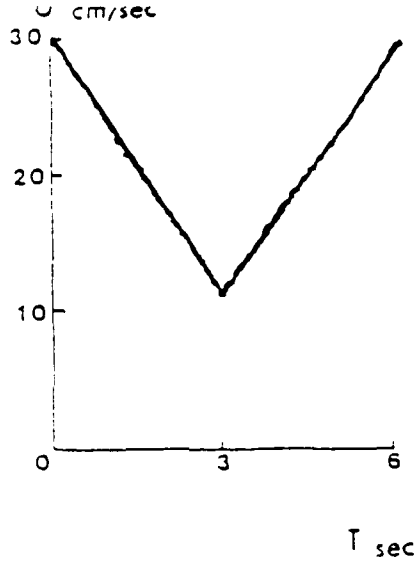

Fig. 5. Free stream velocity with computer-controlled rotating gate.

LIST OF EQUIPMENT ITEMS ACQUIRED DURING THE DURATION OF THE GRANT:

QTY.	DESCRIPTION	MANUFACTURER	UNIT PRICE	TOTAL (Includes shipping, handling, and tax)
1	Netcom, 4x8 back plane #HV1123	Chrislin Ind.	1,195.00	1,249.00
5	Tank adapter 4" dia. PVC Cat#7000-040	Ryan Herco	67.00	356.78
1	Lot fabricate 18" x 18" unsteady water channel facility - constructed of 304 grade stainless steel;Labor and materials	L&F Industries	12,533.33	12,533.33
1	Lot 10Mhz oscilloscope w/ counter timer/multimer Cat#2236	E&I Co-op Tektronix	2,332.00	2,483.58
1	Beckman function generator #FG2	EIL	175.96	196.64
1	12 bit A/D plug in #15-16	RC Electronics	2,495.00	
1	Mass storage upgrade #1SDL-00.4		795.00	3,503.85
1	Basil rewirements for control #RC-2021	RC Electronics	895.00	
1	16 bit arbitrary waveform generator #2161		1,395.00	2,438.85
1	D/A Converter module #55L93	Dantec Elec.	565.25	633.68
1	Lot 12" ship channel-3"	Earl M. Jorgensen	444.00	1,459.35
1	Lot cutting		51.00	
1	Lot 12" standard I beam		572.40	
2	MO93-FC11 DC stepping	Minarik Elec.	215.00	

4	BM133832-009 dropping resistor		15.50	761.48
1	M200T Carver audio power	Gross Nat'n Prod.	319.50	319.50
2	AYA-15 Boston Gear	Garrett Ind.	6.52	
2	AYA-160 Boston Gear	Supply	89.28	204.05
1	1/4-5052-.002x28"x96" Hexaconal	Hexcell	215.60	229.61
1	12" Pitch dia. Spur gear (16 D.P.)	Industrial Sprocket	150.00	
1	3" Pitch dia. Spur gear (16 D.P.)		150.00	319.50
1	New water channel development labor and materials	USC Engr. Shop	1,991.00	1,991.00
1	Fabricate 2 laser drives support	USC Engr. Shop	310.00	310.00
1	BCC-52 Controller board	The Micromint, Inc.	254.54	254.54
1	58 hrs./materials for stepping motor support structure	USC Engr. Shop	949.00	949.00
1	CCK3 Vector card cage	Empire	62.50	
1	3662 Vector circuit card	Electronics	11.95	
1	4112-4 Vector curcuit		18.65	
1	Lot R644 Vector receptacles		4.97	104.44
2	L&H 5x6x9 la carver end suction centigal pump, w/ option - all 316	L.A. Liquid Handling System	3,685.00	7,849.00
1	M112-FJ327 steppin motor	Minarik Electric Co.	438.00	
	PSD-048 B Power Supplies		365.00	855.20

1	12F9575 1K Potetiometer	Newark Electronics	37.24	
2	12F9575 10K Potetiometer		37.24	
2	12F9575 20K Potetiometer		37.24	
2	81F9439 Unregulated power supply		70.95	349.43
1	Lot Cutting	Earl M. Jorgensen	51.00	
1	Lot 4" Sq. Mesh Tubing		230.88	
1	Lot Cutting		21.00	
4	6 ft. 6"x1/16" pipe	Lakewood Pipe Serv.	80.00	
6	35" cut pipe 6" to 6" pipe, contoured		95.00	
2	40" cut pipe 6" to 7-3/8		90.00	1,139.55
1	6" x 18" x 3/8" plate	Behnmaier Steel	5.37	
	8" x 8" x 11" triangle plate 3/8" thick		51.84	
	1-1/2" x 18" x 3/8" bar		13.20	
	18" x 18" x 1/2" plate		163.04	248.62
2	Function generator, #FG2	EK Instruments	199.95	425.89
1	Everex 3MB RAM board-RAM3000	Altech	375.00	518.66
1	Parallel port		28.00	
1	Deskvue Software		60.00	
10	Quad density disks		24.00	
2	Rolls PVC 3/8" x 49" x 180' foam	Packaging Alternatives	419.00	892.47
2	RLO2 disk	Hamilton Avnet	230.00	489.90
6	3/8" PL 10x7	Behnmaier Steel	5.28	
2	3/8" PL 12x7		5.93	46.37
4	18" x 18" x 1/2" Neoprene isolation pads	Cal Dynamics	42.53	181.18
1	PM section No. 9055x0083	Dantec	2,735.00	12,840.81
1	Beamsplitter-color 448nm + 514nm		2,820.00	
1	Pinhole section, 55x31		2,195.00	
1	Color separator		2,150.00	
1	Interference filter, 488nm		520.00	
1	Frequency shifter channel		2,010.00	

3	MTO 3-1/2" P.D. nylon gear 3/4" face		55.00	
5	MTO 7" P.D. nylon gear 3/4" face		88.00	1,123.58
1	Modulynx, stepping motor driver	Minarik Electric	3,163.00	4,549.68
1	Slo-syn stepping motor, MH172-FD8030		1,109.00	
1	Lot safety valves, elbow valves, etc.	Harrington Plastics	1,514.44	1,514.44
1	Polyeth tank 48" x 24" x 12"	Ryan Herco	159.75	380.01
1	Duo block series, true union ball & materials, etc.			
5	CNI 6004s	Inter-American	15.00	79.88
1	10 mesh standard sq. stainless steel wire	Citywire	424.32	539.83
1	10 mesh standard sq. stainless steel			
100	Ft. 2" x 2" stainless square tubing	Ace Stainless	7.10	756.15
70	70 ft., 0,250" in. dia buna-n seal shore 50 hardness	Dimension seal	.71	52.93
1	Wire FDM cut on 24" x 30" stainless steel gate	Microcut	765.00	814.73
11	VT-800 vibration isolation pad	Cal Dynamics	62.00	66.03
1	Lot materials for flow dist. manifold	Harrington Plastics	116.39	116.39
1	12 ft. rod s.s. 303 5/8" dia.	McMaster-Carr	42.46	
1	12 ft. rod, No. 8984K14		27.19	
10	Ft. light weight lock-nut, 91831A035		2.87	
5	Light weight lock-nut, 91831A033		1.11	110.65
100	Ft. 1-1/2" x 1-1/2" O.D. x .12 D sq. tubing	Tube Sales	596.40	596.40
1	Pick-up 2 x 2 sq. stainless Steel Tubing	Ernst Air Speed Trucking	30.77	30.77

1	Installation of duplex receptacles	USC Physical Plant	418.00	
1	Installation of power switches		1,370.00	1,788.00
2	20" long low pressure water filter	Harrington Plastics	36.60	220.35
10	20" long water filter cartridges		6.25	
10	20" long water filter cartridges		7.02	
1	Labor verticle water channel test section	USC Engr. Shop	5,171.00	5,171.00
1	Lot supplies for degassing unit	C&H Sales	259.86	259.86
1	Lot supplies for test section	McMaster Carr	193.08	195.97
1	Base plate of gate for water channel	USC Engr. Shop	1,965.00	1,965.00
1	Fabrication of stepping motor	Physical Plant	40.73	40.73
1	Labor on vertical water channel	Engr. Shop	359.82	359.82
1	APL 100D 208V circuit (DD 5742)	USC Physical Plant	836.54	836.54

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